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D2.2. Best practice pedagogical guideline for application of flipped work-based learning in CNC milling machines.

Meldal VET school

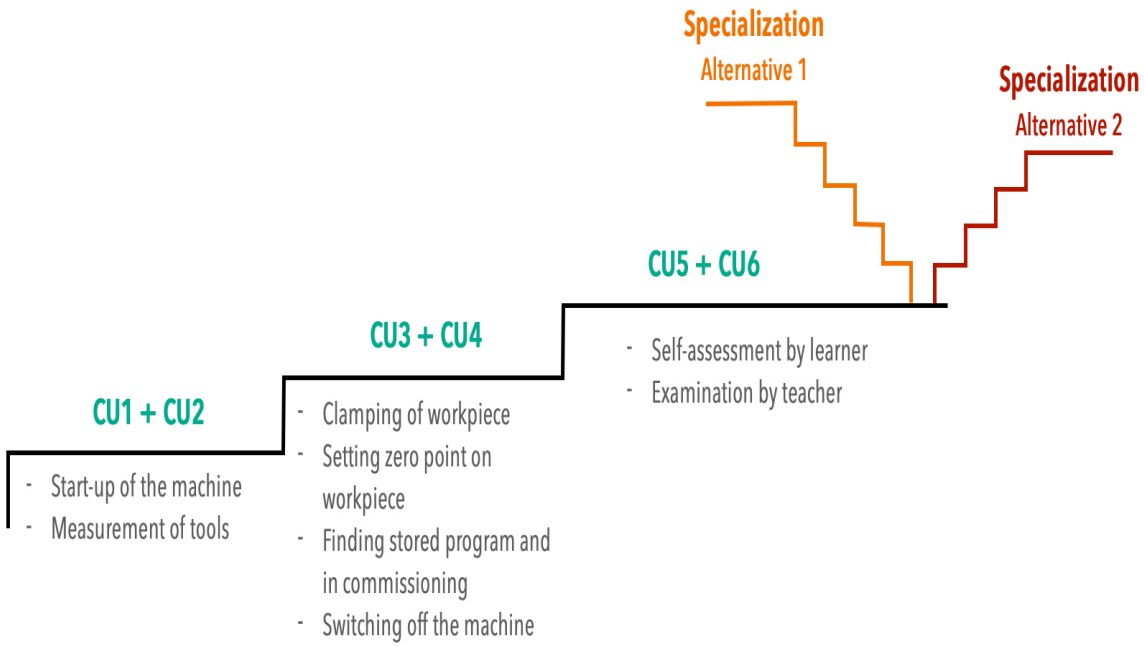
Content
This curriculum includes basic training in the start-up and commissioning of a CNC mill. The training is carried out by application of a flipped classrooms methodology, in which the student studies films that show the process both before and during the training.

General learning outcomes
The candidate will achieve basic competence in the start-up of a CNC-controlled milling machine and be ready for further training in programming.

Specific learning outcomes.
- Start-up of the machine
- Measurement of tools
- Clamping of workpiece
- Setting zero point on workpiece
- Finding stored programme and in commissioning
- Switching off the machine

Competence objectives
- The student must be able to start up and run the selected programme on a CNC mill.
- Be able to verify that the manufactured product fulfils the specific requirements and report any deviations.

The competence ladder for introductory training in CNC milling is shown in the figure below.



Starting up (CU 1-2), Implementation (CU3-4), Final inspection of product (CU5-6)

- CU 1 – Qualifying prior knowledge.
- CU 2 – Self-study of video material
- CU 3 – Initial review
- CU 4 – Practical implementation with support of video materials
- CU 5 – Evaluation and self-assessment by student
- CU 6 – Assessment of competence achieved by the teacher

CU 1 - Qualifying prior knowledge

The student must have had training and be able to operate manual milling machines. This involves knowledge of the machine's working directions in the X, Y and Z axes (including + and - direction). Knowledge of different materials in both the cutting tool and the material to be cut must also be demonstrated. This is a prerequisite for being able to set the correct cutting data on the machine. The cutting data describes the speed at which the machine is to be run and the speed at which the tool can be fed through the workpiece.

CU 2 - Self-study of video material

Here the students should familiarise themselves with the videos and their content. They should do this individually, so this can be given as a homework assignment before practising on the actual machine. Direct links have been created through QR codes so that students can easily find the right instructional film. This gives the students an opportunity to better understand what is being covered when the introductory review starts.

CU 3 - Initial review.

In the introductory review, the instructor provides a theoretical review of the process, while demonstrating the task the students will perform on the machine itself. This can be done for a group of students, where the size of the student groups can be customised based on the level of prior knowledge.

CU 4 - Practical implementation with support from video materials

In this sequence, the students will complete the tasks on the machine, using the video material to help them progress step by step through the task. Here they can work in pairs, while the instructor supervises the process.

Tasks adapted for students after Vg1 Technology and industrial subjects are as follows:

- Start-up of the machine
  - Here, the start-up procedure for the machine is reviewed, based on the machine being completely switched off.
- Measurement of tools
  - In order for the machine to know where the end of the tools are, it must be told how far they protrude from the spindle of the machine and what diameter the tool has.
  - The tools are named to indicate the type of tool.
  - The data is stored in a numbered list in the machine's control unit.
  - This process also includes checking the condition of the tools.
- Clamping of the workpiece
  - Video shows the correct clamping of a workpiece in the machine vice.
- Setting the zero point on the workpiece
  - For the machine to know where in the machine the workpiece is located, a zero point (the workpiece's origin) must be set. This is done by using a 3D probe that is inserted into the machine spindle and then moved towards the point on the workpiece that we want to have as the zero point (usually in the nearest left-hand corner or at the centre of the workpiece). This point is set to 0 in the X, Y and Z axes.
- Finding the saved programme and commissioning
  - Here, the video shows how to navigate the control unit's menus to find a programme that is already stored in the machine and how to start it.
  - This also includes selecting and inserting the correct tool based on what the programme tells us.
- Switching off the machine
  - This last video shows the procedure for completely shutting down the machine again.
  - The machine is cleaned and prepared for new tasks.

  Students should repeat the processes several times until they feel that the support from the videos is less and less necessary.
- Final dimensional control

CU 5 – Self-assessment by learner

- The student's self-assessment of what he/she has learnt in the process (all goals in the staircase).
- This involves the use of different measuring tools (calipers, micrometer analogue/digital).
- The student reviews a self-assessment of how the process has gone and provides feedback to the instructor on what they think has gone well and what may have been challenging. This is done through a questionnaire on It`sLearning or similar platforms. Feedback can then help to highlight areas where the teaching method can be further improved.

CU 6 – Instructor's assessment of learner

- The instructor evaluates how the learner works independently without using the training videos.
- The instructor reviews how the student's achieved competence is perceived by assessing how independent the candidate is in a practical test after completing the training.
- This will show whether the candidate is ready for the next competency step, or whether the process needs to be repeated several times.